DOCUMENT RESUME

ED 124 565 TM 005 208

AUTHOR Subkoviak, Michael J.; Roecks, Alan L.
TITLE A Closer Look at the Accuracy of Alternative Multidimensional Scaling Data Collection Methods.
NOTE 32p.

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS College Students; *Comparative Analysis; *Data Collection; *Distance; Geographic Location; *Methods; *Multidimensional Scaling; Questionnaires; Sorting Procedures
IDENTIFIERS *Cognitive Distance Questionnaire

ABSTRACT

Three different methods of data collection in which subjects judged proximity between object pairs were examined. One method required subjects to partition objects into homogeneous subsets; the second entailed rating object pairs on a similarity-dissimilarity continuum; and the third involved comparing interobject proximities to a fixed standard. The three types of proximities were analyzed by the nonmetric multidimensional scaling procedure, and subsequent multidimensional representations were compared for accuracy to a criterion or true multidimensional configuration of the same objects. Significant differences in accuracy were found among the three methods, presumably due to differences in the extent to which subjects were able to describe their perceptions under the various methods. (Author/RC)

A Closer Look at the Accuracy of Alternative Multidimensional Scaling Data Collection Methods

Michael J. Subkoviak

Alan L. Roecks

The University of Wisconsin

Running Head: The Accuracy of Alternative Data Collection Methods

Abstract

This study examined three different methods of data collection in which subjects judged proximity between object pairs. One method required subjects to partition objects into homogeneous subsets; the second entailed rating object pairs on a similarity-dissimilarity continuum; and the third involved comparing interobject proximities to a fixed standard. The three types of proximities were analyzed by the nonmetric multidimensional scaling procedure, and subsequent multidimensional representations were compared for accuracy to a criterion or true multidimensional configuration of the same objects. Significant differences in accuracy were found among the three methods, presumably due to differences in the extent to which subjects are able to describe their perceptions under the various methods.

A Closer Look at the Accuracy of Alternative Multidimensional Scaling Data Collection Methods

Nonmetric multidimensional scaling procedures are becoming increasingly popular in educational research as a means for graphically representing the network of relationships imbedded within a set of data (Subkoviak, 1975). Given a measure of proximity (similarity or dissimilarity) between each pair of n objects or variables, these procedures represent the objects as points in multidimensional space so that similar objects are close together and dissimilar objects are far apart, or to be specific, so that the rank order of input proximities is the same as the rank order of the corresponding interpoint distances (Kruskal, 1964a, 1964b; Shepard, 1962a, 1962b).

While the mathematical algorithms for locating points in space have been widely discussed and compared (Lingoes & Roskam, 1973; Spaeth & Guthery, 1969; Spence, 1972; Young & Applebaum, 1968), relatively little empirical work has been done to contrast alternative methods of collecting interobject proximities, particularly in regard to the accuracy of resulting multidimensional representations.

Coombs (1964), Torgerson (1958) and Wish (1972) have compiled taxonomies of commonly used procedures for collecting proximity data, and Taylor (1969) has discussed the issues involved in selecting among these alternatives. Taylor and Kinnear (1971) also published an empirical comparison of six methods for determining proximities among seven automobiles, as perceived by 14 college students. The students judged proximities in each of the following ways.

1. *Dyads.* All possible pairs of object pairs $\{(O_i,O_j),(O_k,O_l)\}$ were presented, and subjects picked the most similar pair in each case.

2. *Triad I.* All possible triples (O_i,O_j,O_k) were presented, and subjects chose the object most similar to the first object O_i. Each object in turn filled the first position.

3. *Triad II.* All possible triples (O_i,O_j,O_k) were presented, and subjects selected the most similar and least similar pairs of the three objects.

4. *Rank Order.* Subjects ordered the $\binom{n}{2}$ object pairs (O_i,O_j) from most to least similar.

5. *Rating Scale.* Subjects rated the similarity of each pair (O_i,O_j) on a Likert scale.

6. *Conditional Rank.* Subjects ordered the (n-1) remaining objects in terms of similarity to a given object. Each object in turn served as the standard.

Rank order correlations between these methods, across the n(n-1)/2 obtained proximities, were quite high, with a median value of .84 and a range of .76 to .92, thus indicating that the order of proximities and, by implication, the order of interpoint distances, was reasonably stable across methods. Cluster analysis of the 6 x 6 correlation matrix suggested two somewhat distinct classes of methods and corresponding multidimensional representations: (a) dyads, rank order and rating scale and (b) triad I, triad II and conditional rank. The former class was subjectively rated by subjects as less accurate, more difficult, and less enjoyable than the latter.

Rao and Katz (1971) *simulated* proximities for seven different data collection methods to reflect the distances between 40 cities in Southeast Asia. Some of the methods involved grouping neighboring cities, others required selecting cities nearby a given city, and still others entailed ordering cities with respect to their distance from a specified city. For each of the seven methods, the $\binom{40}{2}$ distances between cities in a two-dimensional representation were correlated with the corresponding geographic distances, providing measures of reproduction accuracy different from the intermethod consistency coefficients computed in the Taylor-Kinnear study. The simulated select and order methods generally appeared to product more accurate reproductions than grouping methods, although differences among methods were not tested for significance.

Neidell (1972) compared three methods (basically Procedures 3, 5 and 6 of the Taylor-Kinnear study) for determining proximities among six drug brands in each of two classes (tranquilizers and antiobesity pills), as perceived by general practitioners. In each of the six (method by drug class) conditions, physicians were contacted by one of three survey techniques--single mailing, double mailing, or telephone. The dependent measures were response rate and proportion of fully completed returns, the latter variable being one determinant of representational accuracy. Significant differences at the .05 level in the proportion of fully completed responses were found between collection methods, but not between drug classes or survey techniques. Procedure 3 yielded fewer completed returns than the other two.

More recently, Henry and Stumpf (1975) compared three methods (Procedures 3, 4 and 6 of the Taylor-Kinnear study) for determining the distances between 7, 9, 11, 13 and 15 U. S. cities as perceived by 15 college students in each of the 15 (method by stimulus set) conditions. One of the dependent variables considered was accuracy, as measured by the rank order correlation between interpoint distances in a two-dimensional representation and the corresponding geographic distances (see the Rao and Katz study above). A two-way analysis of variance indicated no significant differences in accuracy across either methods or stimulus sets, and the interaction of the two factors was also nonsignificant--all tests being performed at the .05 level.

Independent of the Henry-Stumpf study, the present research employed similar procedures to compare the accuracy of three data collection methods across two object sets. However, the methods considered, the measure of accuracy employed, and the final results were quite different from those of Henry and Stumpf.

Methodology

Subjects

A total of 600 undergraduate and graduate students at the University of Wisconsin participated in the study.

Stimuli

The subjects were asked to judge the intercity distances between 10 U.S. cities. Two sets of 10 cities were considered: (a) Set 1 ≡ {Philadelphia, Baltimore, Detroit, Atlanta, Chicago, New Orleans, Denver, Phoenix, Seattle, Los Angeles} and (b) Set 2 ≡ {Detroit, Cincinnati, Atlanta, Minneapolis, St. Louis, Kansas City, New Orleans, Denver, Phoenix, Houston}. The $10(10-1)/2 = 45$ intercity distances of Set 1 are heterogeneous (standard deviation 660 miles) while those of Set 2 are homogeneous (standard deviation 365 miles). Thus, intercity distances of Set 1 are generally easier to differentiate than those of Set 2.

Data Collection Methods.

Subjects judged the intercity distances in one of three ways--sorting, rating, or comparing. As explained below, these methods differ essentially in the number of response categories or scale points that subjects are permitted to use in judging the intercity distances. As such, the methods vary in the completeness with which subjects can report perceived differences among the 45 intercity distances.

1. *Sorting.* As in the Rao and Katz study (1971), subjects sorted the 10 cities into mutually exclusive and exhaustive groups so that cities in the same group were nearer to each other than to cities in other groups. The proportion of times pair (O_i, O_j) was sorted into the same group was tabulated as the proximity measure. Analogously, this proportion can be viewed as the average rating for pair (O_i, O_j) on a *2-point* (zero-one) response scale.

This type of index has been employed in multidimensional analysis of personality traits (Rosenberg, Nelson & Vivekananthan, 1968), nations (Wish, Deutsch & Biner, 1970) and university faculty (Subkoviak & Levin, 1974). The judgment required is quite simple, and thus the method is particularly appropriate for use with unsophisticated subjects and/or complex object properties. Another advantage of the procedure is that subjects can respond to a large number of objects in a relatively short span of time. A distinct disadvantage of this approach is that a single sorting provides no information about proximity differences between objects within the same group or about proximity differences between groups. These shortcomings can be remedied, but at the expense of time and simplicity. For example, after the initial grouping, subjects could be asked to judge proximities between different groups or between objects within the same group.

2. *Rating*. As in the Taylor-Kinnear (1971) and Neidell (1972) studies, subjects judged the distances between all 45 pairs of cities on a *10-point* Likert scale, i.e., SIMILAR : 0 1 2 3 4 5 6 7 8 9 : DISSIMILAR. The average rating for pair (O_i, O_j) was computed as the proximity index.

This type of measure has been employed in multidimensional analyses of geometric figures (Attneave, 1950), attitudes (Messick, 1954) and interpersonal relations (Wish, Kalplan & Deutsch, 1973). A number of variations in the mode of object presentation and the type of rating scale are possible (Torgerson, 1958; Wish, 1972); but the judgmental task remains basically one of judging the absolute proximity of each object pair, as opposed to judging the proximity of one pair relative to that of another pair (see the comparison method discussed below). Complete information is obviously obtained about all n(n-1)/2 interobject proximities, at the expense of time and subject fatigue as n becomes large.

3. *Comparing*. Subjects reported the distance between each pair of cities (O_i, O_j) as a percentage of the distance between New York City and San Francisco, which is essentially a *100-point* scale. The average percentage for pair (O_i, O_j) was taken as the proximity.

This approach has bee used with much success in judging the geographic proximity of various world cities (Lundberg & Ekman, 1973), and the method generalize asily to other types of stimuli. Like rating, the comparison method produces complete information about interobject proximities for a greater investment of time. In addition, this procedure may tend to produce more valid and consistent data than rating if subjects perceive the standard (distance between New York City and San Francisco) as more stable and well-defined than a Likert scale.

Procedure

The three data collection methods were completely crossed with the two stimulus sets for a total of six conditions, and a different form of questionnaire was prepared for each condition. The six forms of the questionnaire were arranged in cyclical order and distributed to entact classes of communication arts and educational psychology students, randomizing the assignment of 100 subjects to each condition (Underwood, 1966, p. 115). In so doing, subjects were told that their questionnaires were not necessarily the same as those of their neighbors, but they were given no additional or specific information as to the nature of the experiment. Subjects then performed the sorting, rating or comparing task at their own rate and then broke a seal on the last page of the questionnaire and made a copy of their own cognitive map by locating the 10 cities in the stimulus set on a completely blank outline representation of the Continental United States on which no man-made or natural features were depicted. The subjects were instructed to complete the map without referring to their previous sorting, rating or comparing responses, so as to maintain some degree of independence between the two tasks. As subjects completed their maps, they returned their materials to the experimenter who recorded the total time required to complete the questionnaire plus map.[1]

The intercity distances on the cognitive map were used to determine the accuracy of sorting, rating and comparing judgments as previous studies have employed actual geographic maps (Henry & Stumpf, 1975; Rao & Katz, 1971). Since a number of studies have demonstrated that a person's cognitive map may deviate significantly from its geographic counterpart (Shepard, 1957, 1972), it was felt that the cognitive map from which sorting, rating and comparing judgments were derived was a better standard by which to assess the accuracy of those judgments than a possibly aberrant geographic map.

Analysis

The group of 100 subjects in each condition was randomly partitioned into 10 subgroups of 10 subjects; and a separate multidimensional representation was recovered for each subgroup as follows.

A numerical judgment S_{ij} of the proximity between the 45 possible pairs of cities was obtained for each subject, small numbers indicating that a pair was geographically close and large numbers meaning the opposite. In the sorting task a pair was coded 0 if a subject placed those two cities in the same cluster or 1 if they were placed in different clusters; in the rating task pairs were scored 0 through 9; and in the comparing task pairs were generally scored 0 through 100 percent (a few pairs were judged greater than 100 percent of the standard by a small number of subjects). Scores S_{ij} for pair (O_i, O_j) were then averaged across the 10 subjects in each subgroup to obtain a subgroup proximity measure $\bar{S}_{ij} = \Sigma S_{ij}/10$ for the pair.

The proximity measures $\bar{S}_{ij}$ were next input into a nonmetric multidimensional scaling program MINISSA-I (Lingoes, 1973), and a two-dimensional representation of the 10 cities (defined by numerical coordinates) was obtained for each subgroup. The 45 Euclidean distances $d_{ij} = \sqrt{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2}$ were computed between all pairs of cities in the representation, where (x_{i1}, x_{i2}) are the two-dimensional coordinates locating city O_i in the configuration for the 10 subjects. The purpose of the study was to compare these MINISSA-I distances for accuracy to the 45 corresponding distances between cities on the cognitive maps of the same 10 subjects.

Accordingly, the coordinates (X_{i1}, X_{i2}) locating each city O_i on each of the 10 cognitive maps were obtained using an electronic digitizer that determines coordinates in units of 1/200[ths] of an inch.[2] Euclidean distances $D_{ij} = \sqrt{(X_{i1} - X_{j1})^2 + (X_{i2} - X_{j2})^2}$ were obtained for each subject and averaged to provide a subgroup measure $\overline{D}_{ij} = \Sigma D_{ij}/10$ of the cognitive distance between pair (O_i, O_j).

For purposes of comparison, the MINISSA-I distances d_{ij} were transformed to the same units of measure (1/200[ths] of an inch) as cognitive distances $\overline{D}_{ij}$. The new MINISSA-I distances were given by $d'_{ij} = a \cdot d_{ij}$ where $a = \Sigma d_{ij}\overline{D}_{ij}/\Sigma d^2_{ij}$ is chosen to minimize $\Sigma(\overline{D}_{ij} - d'_{ij})^2$. This is an admissible linear transformation of ratio scale distances (Lord & Novick, 1968, p. 21) and corresponds to a uniform shrinking of the MINISSA-I configuration to make it comparable to the cognitive map.

Finally, the typical percentage of discrepancy between cognitive $\overline{D}_{ij}$ and MINISSA-I d'_{ij} across all 45 distances was computed as the measure of correspondence between the cognitive maps and the sorting, rating or comparing judgments of the 10 subjects (Kruskal, 1964a, p. 15).

$$\text{Percent Error} = \sqrt{\frac{\sum_{1}^{45} [\overline{D}_{ij} - d'_{ij}]^2}{\sum_{1}^{45} \left[\frac{\overline{D}_{ij} + d'_{ij}}{2}\right]^2}}$$

For example, as shown in Table 1 for sortings of Set 1 cities, interpoint distances d'_{ij} typically differ from cognitive distances $\overline{D}_{ij}$ by 49 percent.

Results and Discussion

Table 1 shows the mean percentage of discrepancy between cognitive distances $\overline{D}_{ij}$ and MINISSA-I distances d'_{ij} and the standard deviation for each condition. The two-way, fixed-effects analysis of variance for these data is shown in Table 2.

Insert Tables 1 and 2 about here

As indicated, there was a significant difference in representational accuracy across data collection methods and stimulus sets; and the interaction was also significant. Methods accounted for (.768/1.310) x 100 = 57 percent of the accuracy variance; stimuli accounted for only (.055/1.310) x 100 = 4 percent; and interaction accounted for (.165/1.310) x 100 = 13 percent, leaving 26 percent of the total variance unaccounted for (Marascuilo, 1971, p. 365). Thus, method of data collection was the most important determinant of representational accuracy, while stimulus set had little real effect.

Scheffé post hoc comparisons of the three method means at the .05 level indicated that sorting was significantly less accurate than either rating or comparing, while there was no significant difference between the latter two methods (Marascuilo, 1971). A study by Green and Rao (1970) offers a possible explanation for these outcomes. Using *simulated* data, they found that scales with only 2 or 3 response categories for judging proximities resulted in less accurate multidimensional representations than scales with 6 or 18 categories. The present study suggests that this finding extends to the *real world*. Sorting involved only 2 categories, whereas rating and comparing involved 10 and 100 or more categories, respectively.

While the difference in accuracy between Sets 1 and 2 was significant, perhaps the more interesting finding with respect to this factor was that these quite different stimuli sets accounted for only 4 percent of the variance in the dependent variable. Thus the effect of stimuli was relatively less important than the other sources of variance considered in the study.

Scheffé post hoc analyses of simple interactions at the .05 level indicated that the *increase* in accuracy from Set 1 to Set 2 for sorting was significant compared to that for rating or comparing. Moreover, there was no significant difference between rating and comparing in this regard. The apparent reason is as follows. For the more widely dispersed cities of Set 1, most subjects formed the same clusters. Therefore, a bimodal proximity distribution of 0's and 1's occurred that did not correspond well to the unimodal distribution of actual cognitive distances. On the other hand, greater variability in defining clusters for the more tightly knit cities of Set 2 produced a distribution of proximities that compared more favorably to that of the cognitive distances, thus the increase in accuracy from Set 1 to Set 2 for the sorting method. However, in rating and comparing tasks, obtained proximities for both Sets 1 and 2 compared almost equally well to the distribution of cognitive distances; thus there was little change in accuracy across sets.

The primary conclusion to be drawn from the study is that sorting tends to produce less accurate multidimensional configurations than either rating or comparing for groups of 10 subjects. Interestingly, as shown in Table 3, the accuracy of Set 2 sorting, i.e., *sortings that vary across subjects*, appears to become more equivalent to that of the other two procedures as the number of subjects increases. Since sorting requires less time than rating or comparing--about 7 1/2 as opposed to 11 and 11 1/2 minutes in the present study, the former method may be a reasonable alternative if stimuli are conducive to variable clustering and 20 or more subjects are employed. Moreover, since sorting time is a function of n, whereas rating and comparing times are a function of n(n-1)/2, the saving in time and effort increases markedly as n increases.

References

ATTNEAVE, F. Dimensions of similarity. American Psychologist, 1950, 63, 516-556.

COOMBS, C. H. Theory of data. New York: Wiley, 1964.

GREEN, P. E. & RAO, V. R. Rating scales and information recovery--How many scales and response categories to use. Journal of Marketing, 1970, 34, 33-39.

HENRY, W. A. & STUMPF, R. V. Time and accuracy measures for alternative multidimensional scaling data collection methods. Journal of Marketing Research, 1975, 12, 165-170.

KRUSKAL, J. B. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. Psychometrika, 1964, 29, 1-27 (a).

KRUSKAL, J. B. Nonmetric multidimensional scaling: A numerical method. Psychometrika, 1964, 29, 115-129.

LINGOES, J. C. The Guttman-Lingoes nonmetric program series. Ann Arbor, Mich.: Mathesis Press, 1973.

LINGOES, J. C. & ROSKAM, E. E. A mathematical and empirical analysis of two multidimensional scaling algorithms. Psychometrika Monograph Supplement, 1973, 38 (4, Part 2, Monograph No. 19).

LORD, F. M. & NOVICK, M. R. Statistical theories of mental test scores. Reading, Mass.: Addison-Wesley, 1968.

LUNDBERG, U. & EKMAN, G. Subjective geographic distance: A multidimensional comparison. Psychometrika, 1973, 38, 113-122.

MARASCUILO, L. A. Statistical methods for behavioral science research. New York: McGraw-Hill, 1971.

MESSICK, S. J. The perception of attitude relationships: A multidimensional scaling approach to the structure of social attitudes. (Doctoral dissertation, Princeton University) Ann Arbor, Mich.: University Microfilms, 1955, No. 55-1228).

NEIDELL, L. A. Procedures for obtaining similarities data. Journal of Marketing Research, 1972, 9, 335-337.

RAO, V. R. & KATZ, R. Alternative multidimensional scaling methods for large stimulus sets. Journal of Marketing, 1971, 8, 488-494.

ROSENBERG, S., NELSON, C. & VIVEKANANTHAN, P. S. A multidimensional approach to the structure of personality impressions. Journal of Personality and Social Psychology, 1968, 9, 283-294.

SHEPARD, R. N. Multidimensional scaling of concepts based upon sequences of restricted associative responses. American Psychologist, 1957, 12, 440-441. (abstract).

SHEPARD, R. N. The analysis of proximities: Multidimensional scaling with an unknown distance function. I. Psychometrika, 1962, 27, 125-140. (a)

SHEPARD, R. N. The analysis of proximities: Multidimensional scaling with an unknown distance function. II. Psychometrika, 1962, 27, 219-246. (b)

SHEPARD, R. N. Some illustrative applications. Paper presented at the Bell-Penn Workshop on Multidimensional Scaling, Philadelphia, June, 1972.

SPAETH, H. J. & GUTHERY, S. B. The use and utility of the monotone criterion in multidimensional scaling. Multivariate Behavioral Research, 1969, 4, 501-515.

SPENCE, I. A Monte Carlo evaluation of three nonmetric multidimensional scaling algorithms. Psychometrika, 1972, 37, 461-486.

SUBKOVIAK, M. J. The use of multidimensional scaling in educational research. Review of Educational Research, 1975, 45, 387-423.

SUBKOVIAK, M. J. & LEVIN, J. R. Determining the characteristics of the ideal professor: An alternative approach. Journal of Educational Measurement, 1974, 11, 269-276.

TAYLOR, J. R. Alternative methods for collecting similarities data. Proceedings of the Fall Conference of the American Marketing Association, 1969, 150-152.

TAYLOR, J. R. & KINNEAR, T. C. Empirical comparison of alternative methods for collecting proximity judgments. Proceedings of the Fall Conference of the American Marketing Association, 1971, 547-550.

TORGERSON, W. S. Theory and methods of scaling. New York: Wiley, 1958.

UNDERWOOD, B. J. Experimental psychology. New York: Appleton-Century-Crofts, 1966.

WISH, M. Notes on the variety, appropriateness, and choice of proximity measures. Paper presented at the Bell-Penn Workshop on Multidimensional Scaling, Philadelphia, June, 1972.

WISH, M., DEUTSCH, M. & BINER, L. Differences in conceptual structures of nations: An exploratory study. Journal of Personality and Social Psychology, 1970, 16, 361-373.

WISH, M., KAPLAN, S. J. & DEUTSCH, M. Dimensions of interpersonal relations: Preliminary results. Paper presented at the 81st Annual Convention of the American Psychological Association, Montreal, 1973.

YOUNG, F. W. & APPLEBAUM, M. I. Nonmetric multidimensional scaling: The relationship of several methods. Report No. 71, L. L. Thurstone Psychometric Laboratory, University of North Carolina, Chapel Hill, N. C., 1968.

Table 1

Mean and Standard Deviation of Percent Error

Across Replications[a]

Stimuli		Method		
		Sorting	Rating	Comparing
Set 1	$\overline{X}$	.49	.18	.11
	S	.15	.12	.03
Set 2	$\overline{X}$	.29	.17	.15
	S	.04	.03	.02

[a]10 subgroups per condition.

Table 2

Analysis of Variance

Source	*df*	*SS*	*MS*	*F*
Method	2	.768	.384	64.00*
Stimuli	1	.055	.055	9.17*
Interaction	2	.165	.083	13.83*
Error	54	.322	.006	
Total	59	1.310		

* Significant at .05 level

Table 3

Mean Percent Error for Subgroups of Various Sizes[a,b,c]

	Method								
	Sorting			Rating			Comparing		
Stimuli	N = 10	N = 20	N = 100	N = 10	N = 20	N = 100	N = 10	N = 20	N = 100
Set 1	.49	.46	.32	.18	.12	.09	.11	.09	.08
Set 2	.29	.21	.14	.17	.16	.17	.15	.14	.15

[a] 10 subgroups of N = 10 subjects.

[b] 5 subgroups of N = 20 subjects.

[c] 1 subgroup of N = 100 subjects.

Footnotes

1. Copies of all instruments used in the study have been filed with the ERIC Clearinghouse on Tests, Measurements and Evaluation under accession number and thus are available from that source.

2. The authors gratefully acknowledge Dr. Wendel K. Beckwith, II of the Geography Department at the University of Wisconsin for his assistance in this phase of the study.

NAME ________________________ DATE __/__/__ COURSE NO. ______

DIRECTIONS

This questionnaire asks about the distances between the following U.S. Cities.

Denver	Kansas City
Phoenix	New Orleans
St. Louis	Detroit
Cincinnati	Houston
Minneapolis	Atlanta

In Item 1 below rate the distance between Cincinnati and Denver on the scale 0,1,2,3,4,5,6,7,8,9. Small numbers 0-4 indicate small distances, and the smaller the number the smaller the distance between the two cities. Large numbers 5-9 indicate large distances, and the larger the number, the larger the distance between the two cities.

Please circle one and only one number 0,1,2,3,4,5,6,7,8,9 in each of the following items.

		SMALL									LARGE
1.	Cincinnati - Denver	0	1	2	3	4	5	6	7	8	9
2.	Cincinnati - Houston	0	1	2	3	4	5	6	7	8	9
3.	Atlanta - Denver	0	1	2	3	4	5	6	7	8	9
4.	Phoenix - Minneapolis	0	1	2	3	4	5	6	7	8	9
5.	New Orleans - St. Louis	0	1	2	3	4	5	6	7	8	9
6.	Kansas City - Denver	0	1	2	3	4	5	6	7	8	9
7.	New Orleans - Houston	0	1	2	3	4	5	6	7	8	9
8.	Houston - Kansas City	0	1	2	3	4	5	6	7	8	9
9.	Atlanta - Detroit	0	1	2	3	4	5	6	7	8	9
10.	Cincinnati - Detroit	0	1	2	3	4	5	6	7	8	9
11.	Detroit - St. Louis	0	1	2	3	4	5	6	7	8	9
12.	Kansas City - Detroit	0	1	2	3	4	5	6	7	8	9
13.	Cincinnati - Kansas City	0	1	2	3	4	5	6	7	8	9
14.	Kansas City - New Orleans	0	1	2	3	4	5	6	7	8	9
15.	New Orleans - Atlanta	0	1	2	3	4	5	6	7	8	9

PLEASE TURN TO THE NEXT PAGE.

		SMALL									LARGE
16.	Houston - Denver	0	1	2	3	4	5	6	7	8	9
17.	Atlanta - Cincinnati	0	1	2	3	4	5	6	7	8	9
18.	Atlanta - Minneapolis	0	1	2	3	4	5	6	7	8	9
19.	Phoenix - Kansas City	0	1	2	3	4	5	6	7	8	9
20.	Minneapolis - St. Louis	0	1	2	3	4	5	6	7	8	9
21.	Detroit - Phoenix	0	1	2	3	4	5	6	7	8	9
22.	Atlanta - Phoenix	0	1	2	3	4	5	6	7	8	9
23.	Denver - New Orleans	0	1	2	3	4	5	6	7	8	9
24.	New Orleans - Phoenix	0	1	2	3	4	5	6	7	8	9
25.	Detroit - Denver	0	1	2	3	4	5	6	7	8	9
26.	Kansas City - St. Louis	0	1	2	3	4	5	6	7	8	9
27.	Atlanta - St. Louis	0	1	2	3	4	5	6	7	8	9
28.	Cincinnati - Minneapolis	0	1	2	3	4	5	6	7	8	9
29.	Cincinnati - St. Louis	0	1	2	3	4	5	6	7	8	9
30.	Minneapolis - Detroit	0	1	2	3	4	5	6	7	8	9
31.	New Orleans - Cincinnati	0	1	2	3	4	5	6	7	8	9
32.	Atlanta - Houston	0	1	2	3	4	5	6	7	8	9
33.	Atlanta - Kansas City	0	1	2	3	4	5	6	7	8	9
34.	Phoenix - Cincinnati	0	1	2	3	4	5	6	7	8	9
35.	St. Louis - Phoenix	0	1	2	3	4	5	6	7	8	9
36.	Kansas City - Minneapolis	0	1	2	3	4	5	6	7	8	9
37.	Denver - Minneapolis	0	1	2	3	4	5	6	7	8	9
38.	Minneapolis - Houston	0	1	2	3	4	5	6	7	8	9
39.	St. Louis - Houston	0	1	2	3	4	5	6	7	8	9
40.	Minneapolis - New Orleans	0	1	2	3	4	5	6	7	8	9
41.	Denver - St. Louis	0	1	2	3	4	5	6	7	8	9
42.	Phoenix - Denver	0	1	2	3	4	5	6	7	8	9
43.	Phoenix - Houston	0	1	2	3	4	5	6	7	8	9
44.	Houston - Detroit	0	1	2	3	4	5	6	7	8	9
45.	Detroit - New Orleans	0	1	2	3	4	5	6	7	8	9

PLEASE TURN TO THE NEXT PAGE.

COMPLETE THE OTHER PARTS OF THE QUESTIONNAIRE

THEN TURN TO THE NEXT PAGE AND CONTINUE.

DIRECTIONS

Do this page last. Be sure you have completed the other parts of the questionnaire before you begin.

Use your mental picture or image of the U.S. to locate the following cities on the map provided below.

1. Denver	6. Kansas City
2. Phoenix	7. New Orleans
3. St. Louis	8. Detroit
4. Cincinnati	9. Houston
5. Minneapolis	10. Atlanta

Use a dot (·) to indicate the location of each city on the map below. Then write the number of each city (1 thru 10 above) over its dot ($\overset{1}{\cdot}$). Please be sure to place all 10 cities on the map.

PLEASE RETURN THE BOOKLET TO THE PROCTOR WHEN YOU HAVE FINISHED.

NAME ______________________ DATE __/__/__ COURSE NO. ______

DIRECTIONS

This questionnaire asks about the distances between the following U.S. cities.

Los Angeles	Chicago
Phoenix	Denver
Baltimore	New Orleans
Detroit	Atlanta
Seattle	Philadelphia

Imagine that the distance between New York City and San Francisco equals 100 units. Now compare the distances between the cities above to the distance between New York City and San Francisco. For example, the distance between Detroit and Los Angeles is what percent of the distance between New York City and San Francisco? Record your answer in Item 1 below.

Complete all the other items in the same way. Compare the distance between the given cities to the distance between New York City and San Francisco, and then record your answer as a percent.

1. Detroit - Los Angeles is ____% of New York City - San Francisco
2. Atlanta - Detroit is ____% of New York City - San Francisco.
3. Philadelphia - Los Angeles is ____% of New York City - San Francisco
4. Phoenix - Seattle is ____% of New York City - San Francisco
5. Baltimore - Denver is ____% of New York City - San Francisco
6. Chicago - Los Angeles is ____% of New York City - San Francisco
7. Denver - Atlanta is ____% of New York City - San Francisco
8. Atlanta - Chicago is ____% of New York City - San Francisco
9. Philadelphia - New Orleans is ____% of New York City - San Francisco
10. Detroit - New Orleans is ____% of New York City - San Francisco
11. New Orleans - Baltimore is ____% of New York City - San Francisco
12. Chicago - New Orleans is ____% of New York City - San Francisco
13. Detroit - Chicago is ____% of New York City - San Francisco
14. Chicago - Denver is ____% of New York City - San Francisco
15. Denver - Philadelphia is ____% of New York City - San Francisco

PLEASE TURN TO THE NEXT PAGE.

16. Atlanta - Los Angeles is ____% of New York City - San Francisco
17. Philadelphia - Detroit is ____% of New York City - San Francisco
18. Philadelphia - Seattle is ____% of New York City - San Francisco
19. Phoenix - Chicago is ____% of New York City - San Francisco
20. Seattle - Baltimore is ____% of New York City - San Francisco
21. New Orleans - Phoenix is ____% of New York City - San Francisco
22. Philadelphia - Phoenix is ____% of New York City - San Francisco
23. Los Angeles - Denver is ____% of New York City - San Francisco
24. Denver - Phoenix is ____% of New York City - San Francisco
25. New Orleans - Los Angeles is ____% of New York City - San Francisco
26. Chicago - Baltimore is ____% of New York City - San Francisco
27. Philadelphia - Baltimore is ____% of New York City - San Francisco
28. Detroit - Seattle is ____% of New York City - San Francisco
29. Detroit - Baltimore is ____% of New York City - San Francisco
30. Seattle - New Orleans is ____% of New York City - San Francisco
31. Detroit - Denver is ____% of New York City - San Francisco
32. Atlanta - Philadelphia is ____% of New York City - San Francisco
33. Philadelphia - Chicago is ____% of New York City - San Francisco
34. Phoenix - Detroit is ____% of New York City - San Francisco
35. Baltimore - Phoenix is ____% of New York City - San Francisco
36. Chicago - Seattle is ____% of New York City - San Francisco
37. Los Angeles - Seattle is ____% of New York City - San Francisco
38. Seattle - Atlanta is ____% of New York City - San Francisco
39. Baltimore - Atlanta is ____% of New York City - San Francisco
40. Seattle - Denver is ____% of New York City - San Francisco
41. Los Angeles - Baltimore is ____% of New York City - San Francisco
42. Los Angeles - Phoenix is ____% of New York City - San Francisco
43. Phoenix - Atlanta is ____% of New York City - San Francisco
44. Atlanta - New Orleans is ____% of New York City - San Francisco
45. New Orleans - Denver is ____% of New York City - San Francisco

PLEASE TURN TO THE NEXT PAGE.

COMPLETE THE OTHER PARTS OF THE QUESTIONNAIRE

THEN TURN TO THE NEXT PAGE AND CONTINUE.

DIRECTIONS

Do this page last. Be sure you have completed the other parts of the questionnaire before you begin.

Use your mental picture or image of the U.S. to locate the following cities on the map provided below.

1.	Los Angeles	6.	Chicago
2.	Phoenix	7.	Denver
3.	Baltimore	8.	New Orleans
4.	Detroit	9.	Atlanta
5.	Seattle	10.	Philadelphia

Use a dot (·) to indicate the location of each city on the map below. Then write the number of each city (1 thru 10 above) over its dot ($\overset{1}{\cdot}$). Please be sure to place all 10 cities on the map.

PLEASE RETURN THE BOOKLET TO THE PROCTOR WHEN YOU HAVE FINISHED.

NAME ______________________ DATE __/__/__ COURSE NO. ______

DIRECTIONS

This questionnaire asks about the distances between the following U.S. cities.

Los Angeles	Chicago
Phoenix	Denver
Baltimore	New Orleans
Detroit	Atlanta
Seattle	Philadelphia

Sort the cities into separate groups in the blank space below, so that cities in the same group have small distances between them and are near one another. Please sort each city into one and only one group. Draw a circle around each separate group. Use as few or as many groups as you think are necessary; each group may contain as few or as many cities as seem appropriate.

PLEASE TURN TO THE NEXT PAGE

COMPLETE THE OTHER PARTS OF THE QUESTIONNAIRE

THEN TURN TO THE NEXT PAGE AND CONTINUE.

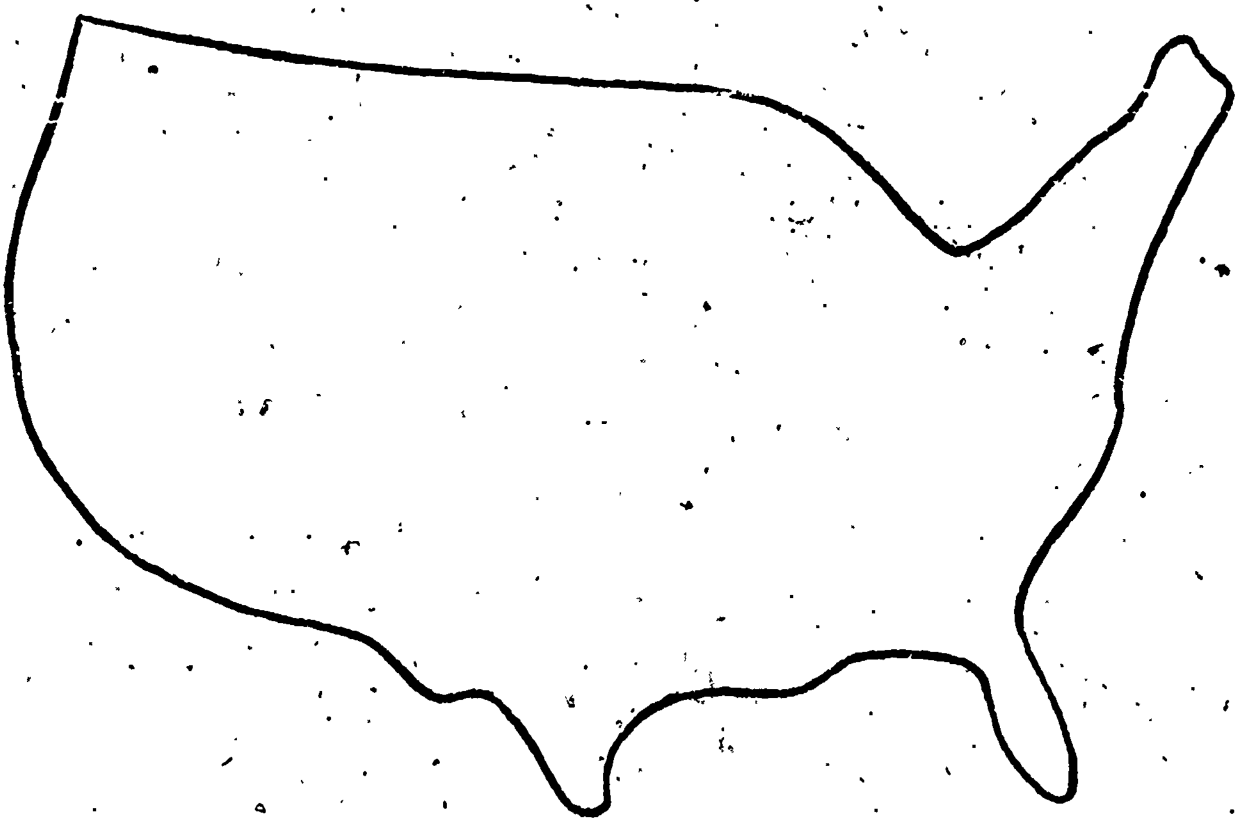
DIRECTIONS

Do this page last. Be sure you have completed the other parts of the questionnaire before you begin.

Use your mental picture or image of the U.S. to locate the following cities on the map provided below.

1.	Los Angeles	6.	Chicago
2.	Phoenix	7.	Denver
3.	Baltimore	8.	New Orleans
4.	Detroit	9.	Atlanta
5.	Seattle	10.	Philadelphia

Use a dot (·) to indicate the location of each city on the map below. Then write the number of each city (1 thru 10 above) over its dot ($\overset{1}{\cdot}$). Please be sure to place all 10 cities on the map.



PLEASE RETURN THE BOOKLET TO THE PROCTOR WHEN YOU HAVE FINISHED.